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APPLICATION FOR UNITED STATES LETTERS PATENT

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FOR: **DISK DRIVE**

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DISK DRIVE

BACKGROUND OF THE INVENTION

1. Technical Field

The present invention relates to a disk drive for playing or driving an information-recording disk, such as a magnetic disk.

2. Related Art

Although the hard disk drives (HDDs) have now being spread as external storage units for personal computers, price reduction has put forwarded as their record density increases. In the recent, there has been an advent of home-use electronic products having built-in HDDs. The HDDs are capable of storing video and music contents in quantity and hence the products utilizing them are placed into marketing one after another. It is expected to mount them upon the car audio products. The DVDs nowadays are in the mainstream in the field of car navigation systems. It is however expected of shift from now on into HDDs.

The basic structure of an HDD is shown in Fig. 1. The HDD adopts a ramp-loading scheme that a float head slider 51 arranged at a tip of the actuator 54 is mechanically floated from a surface of the magnetic disk.

As shown in the figure, the magnetic head 51 on the actuator 54 is arranged for radial movement (shown by arrows) of the magnetic disk 53 and positioned by a voice coil motor (VCM) 160. Although the magnetic head 51 is urged onto the surface of the magnetic disk 53 by an elastic force of the

suspension 57, it is controlled to have a distance of several tens of μm to the disk surface of the magnetic disk 53 due to aerodynamic floating force acting upon the magnetic head 51 by a rotation of the magnetic disk 53. Meanwhile, the magnetic head 51 not in operation is positioned in a retracted position where it is on a taper 56 of a ramp 55 formed at one end of the housing frame 50.

Fig. 2 shows a positional relationship in a sectional view between the magnetic head 51 and the ramp 55. As shown in the figure, the ramp 55 positioned close to the outer periphery of the magnetic disk 53 has a taper 56 given gradually higher than a surface of the magnetic disk 53 in a direction toward a radial outward of the disk. When reading information from or writing information to the magnetic disk 53 (i.e. in driving), the magnetic head 51 positions at a play position (in a position a) with a proper spacing to a main surface of the magnetic disk 53. In out of operation (or in unload), it gets over the taper 56 as shown by the arrow A to reach a retract position, or home position b, for waiting.

In the meanwhile, the foregoing HDD is given a function called emergency unload. The emergency unload function refers to a function that, where power voltage to the motor for driving the spindle 52 and magnetic head 51 is greatly decreased, the head 51 is forcibly moved to the retract position, in order to prevent a magnetic disk 53 from being damaged by the magnetic head 53. A power supply is required for carrying out the emergency unload. There is known an arrangement that, when the

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both power supplies fail, the emergency unloading is performed by the use of a reverse electromotive force, i.e. no-load electromotive force, caused by the inertial rotation of the spindle motor 52.

When the above-mentioned disk drive apparatus is used as a disk drive apparatus mounted on an engine-driven vehicle, a battery voltage greatly decreases at a startup of the engine and accordingly the emergency unload operation as the foregoing will be effected each time the engine is started up.

Fig. 3 shows an example of a power supply circuit in an engine-driven vehicle. That is, an alternator G is driven by an engine, not shown. The alternating current supplied from the alternator G is rectified and smoothed by a rectifier D and then supplied to a battery B. The battery voltage Vb on the battery B is supplied to a movable contact m of an engine-key switch SW. The engine key switch SW has fixed terminals ACC, ON and ST. The battery voltage Vb passed through the terminal ACC is supplied as ACC power to a light load such as an audio unit. The battery voltage Vb passed through the terminal ON is supplied as ON power to a heavy load HL such as a power window actuator. The battery voltage Vb passed through the terminal ST is supplied as an MST voltage to a starter motor (not shown), to rotate the starter motor and start up the engine. On the other hand, the battery voltage Vb is supplied as a backup power to a light load LL through a line BU.

Figs. 4A and 4B show voltage on the power supply lines how the voltages of BACKUP and ACC change at the engine start.

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Fig. 4A depicts a manner of change in power voltage of the backup power supply while Fig. 4B depicts a manner of change in the ACC power supply. Meanwhile, the timings (I), (II), (III) and (IV) respectively correspond to the key switch positions of the engine key. (I) represents a case the engine key is positioned at an ACC position to supply power to a light load such as an audio unit, (II) a case at an ON position to supply power to a heavy load, for example, of the power window actuator or the like, (III) a case at an ST position to supply power to the starter motor and (IV) a case the engine key is returned to the ON position .

During such engine start operations, there is a possibility that the backup power voltage decreases due to drop in the battery voltage. (period (III) (IV) in Figs. 4A and 4B.)

Accordingly, where the HDD is mounted on an engine-driven vehicle, there is a high possibility that such emergency unload operation as mentioned above occur each time the engine is started up due to the drop in the power voltage because of the great amount of power consumption by the starter motor. Because the emergency unload is to forcibly move the head by utilizing the reverse electromotive force of the spindle motor as described above, there are increased occasions in the vehicular-mounted disk drive that the float head slider 51 collide with the taper 56 on the ramp 55 in the course of reaching the wait position b on the ramp 55 as compared to the case where the disk drive is mounted on a home-use device such

as a home-use personal computer. In other words, the vehicular-mounted HDD requires increased endurance for the magnetic head 51. This circumstance is commonly problematic for the disk drive apparatuses for use with unstable power voltage.

SUMMARY OF THE INVENTION

The present invention has been made in view of the above circumstance, and it is an object of the present invention to provide a disk drive apparatus capable of avoiding the decrease in endurance even if it is used under an unstable power supply.

In order to solve the above problem, the present invention provides a disk drive apparatus for controlling, under supply of a predetermined rating voltage of power voltage, a head drive section to position a head in a radial direction of an information recording disk and carry out write and/or read operation of information while rotatively driving the information recording disk by a rotation drive motor, the disk drive apparatus including: a forcible restoring section for controlling the head drive section to forcibly bring the head to a retract position by no-load electromotive force due to the rotation drive motor when the power voltage goes below a first voltage level; and a normal restoring section for controlling the head drive section to move the head toward the retract position on the basis of the power voltage while the power voltage is smaller than the rating voltage but greater than the first voltage level.

BRIEF DESCRIPTION OF THE DRAWINGS

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Fig. 1 is a plan view showing a basic structure of a ramp-load schemed HDD;

Fig. 2 is a sectional view for explaining a positional relationship between a ramp and a head in Fig. 1;

Fig. 3 is a block diagram showing a power supply system for an engine-driven vehicle;

Figs. 4A and 4B are timing charts for explaining changes in power voltages at a start of the engine of the engine-driven vehicle;

Fig. 5 is a block diagram showing a car navigation system including an HDD apparatus of the present invention;

Fig. 6 is a block diagram of an HDD apparatus in the system of Fig. 5;

Figs. 7A through 7D are timing charts showing changes in power voltages for an engine-driven vehicle;

Figs. 8A and 8B are flowcharts showing control operations in the car navigation system according to the present invention; and

Figs. 9A and 9B are sectional views showing a positional relationship between the disk and the head, for showing the operation carried out by the control operations shown by the flowcharts of Figs. 8A and 8B.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. 5 shows a car navigation system including an HDD according to the present invention. Herein, the HDD is used as a map information memory section for a car navigation system. It is now to be noted that the HDD according to the invention

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is used for a variety of devices but not limited to such car navigation. The car navigation system as illustrated has a host CPU 11 serving as a control core and configured with a ROM 12, a RAM 13, a timer LSI (14), an HDD 15, a sensor section 16, a GPS receiver section 17, an interface 18, an input device 19, a display 20, a display control section 21, a display memory 22, a sound processing circuit 23, a speaker 24, a power supply circuit 25, a hard disk controller (HDC) 26 and a backup RAM 27.

The host CPU 11 administers overall control of navigation including search for destination and route guide in cooperation with the display control section 21 depending upon a program stored in the ROM 12 and RAM 13, according to an instruction given from a user through the input device 19. In this case, utilized is geographical information available through the sensor section 16 and GPS receiver section 17. The timer LSI (14) has a time count value set programmable by the host CPU 11 and issues an interrupt at a time-up, thereby to initiate an interrupt process routine.

The HDC 26 administers format control of a magnetic disk loaded on the HDD 15 and, further, has functions as a host interface and an HDD interface.

The sensor section 16 refers to sensors needed in self-controlled traveling as a car navigation system and, for example, a vehicular speed sensor, a gyro-sensor or the like connected to a system bus 10 through the interface 18. The interface 18 is supplied also with an output of the GPS receiver

section 17 to provide hybrid-traveling control based on GPS positioning and self-controlled traveling.

The display 20 is configured, for example, with a liquid crystal monitor to read in and display, through the display control section 21, a process content of geographical information or the like written in the display memory 22 by the host CPU 11.

The input device 19 is a remote control or console to be used as a GUI used to input commands or make communication with the navigation system through the display 20. The sound processing circuit 23 functions to generate a voice guide or as a GUI to dialogue with the navigation system by voice input. The voice guide is outputted through the speaker 24. The reference 25 is a vehicular power supply circuit and includes a backup power supply line and an ACC power supply line, as described above.

Fig. 6 shows a voltage monitor device 30 for detecting voltage values of the backup power and the ACC power of the HDD 15 and vehicular power supply circuit 25.

The vehicular power supply circuit 25 comprises a backup power source line 251 and an ACC power source line 252. The voltage monitor device 30 is formed with a voltage comparator circuit 301 and a threshold setting circuit 302.

The voltage monitor circuit 30 monitors respective voltage values of the powers supplied through the power supply lines 251 and 252 from the backup power supply and the ACC power supply. The threshold setting circuit 302 is set with a

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threshold value to detect voltage drop, the value of which is to be informed to the voltage comparator circuit 301.

The HDD 15 is configured by an CPU 152 built within the HDD as a core, a host interface circuit 151, a program memory 153, a data memory 154, an HDD interface circuit 155, an R/W (read/write) circuit 156, a head-drive control circuit 157, a spindle-motor control circuit 158, a magnetic head 51, a voice coil motor (VCM) 160 and a spindle motor 161.

The host interface 151, the HDD-built CPU 152, the program memory 153, the data memory 154 and the HDD interface circuit 155 are commonly connected to an HDD system bus 150.

The HDD-built CPU 152 receives a command (Seek, Read/Write, etc.) through the host interface circuit 151 from the CPU 11 shown in Fig. 5, to control the R/W circuit 156, head-drive control circuit 157 and spindle-motor control circuit 158 through the HDD interface circuit 155 according to a program stored in the program memory 153. The data to be read from and written to the magnetic disk 53 through the magnetic head 51 is under control of the R/W circuit 156. Meanwhile, the drive to the VCM 160 is under control of the head-drive control circuit 157. Furthermore, the rotation drive to the spindle motor 161 is under control of the spindle-motor control circuit 158. When, incidentally, both of the backup power voltage and the ACC power voltage drop, the reverse electromotive force caused by inertial rotation of the spindle motor 161 is supplied to the VCM 160 through the relay contact and line 170, providing the emergency unload.

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Incidentally, a power switch exclusive for the HDD can be provided on the lines 251, 252 at an upstream of the monitor points 251a, 252a for the voltage monitor circuit 30, for example, at a position surrounded by a broken line B.

Fig. 7A and Fig. 7B are timing charts showing voltage waveforms of the respective power supplies at a startup of the vehicle engine.

Fig. 7A shows a voltage waveform of the backup power supplied through the power supply line 251, while Fig. 7B shows a voltage waveform of the ACC power supplied through the ACC power supply line 252. The voltage waveforms of the both power voltages are similar to the voltage waveforms shown in Figs. 4A and 4B, and detailed explanations are herein omitted.

As described before, there is observed phenomenon that the power voltage value decreases in the period of (I) (IV) in Fig. 3 because of startup current of the starter motor. The voltage waveform at the beginning of the voltage drop is as concretely shown in the circle of the figure, i.e. each power voltage is controlled to drop depicting a moderate curve and then returns without abrupt drop.

Accordingly, the present invention controls such that a voltage value at immediately before starting emergency unload (time A) is detected to perform normal unload operation upon detecting the voltage value. That is, where the normal power voltage or the ACC power voltage is given at 12V, the voltage value for starting normal unload is 9V and the voltage value for starting emergency unload is 4.5V, the voltage value on the

backup power supply or the ACC power supply is monitored. When the voltage value becomes 9V (time A), normal unload is started to start moving the head to a retract-position direction. In the moving process, when the voltage value becomes 4.5V (time B), the circuits such as the host CPU 11 and the HDD-built CPU 152 are reset which results in the emergency unload.

The above operation will now be explained with reference to Figs. 8A and 8B. Fig. 8A shows a routine carried out by the host CPU 11 and Fig. 8B a process by the HDD-built CPU 152.

First, the host CPU 11 monitors whether the power voltage on the ACC power line varying interacting with a key switch is ON, or 12V, or not (step S41). When the ACC power is ON, power is supplied to the overall navigation system of fig. 5, driving a spindle motor 161 of the HDD 15 to rotate. Next, the voltage value α of the backup power 251 is monitored (step S42). The above steps S41 and S42 are executed by monitoring an output signal from a voltage-value monitor circuit 301 shown in Fig. 6.

As a result of monitoring the voltage value on the backup power supply 251, when the voltage value α goes below 9V, the host CPU 11 instructs head normal unload to a head-drive control circuit 157 and the HDD-built CPU 152 instructs normal unload to the head drive circuit 157 (step S43). Thereafter, when the voltage value α goes below 4.5V, the system entirety including the host CPU 11 automatically turns into a reset state, the control on the magnetic head 51 by the head drive circuit 157 is suspended. In the HDD 15, a relay RL is restored to supply

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the reverse electromotive force of the spindle motor 161 to the VCM 160 through a break contact of a contact rl, effecting the emergency unload operation (step S44).

In this manner, the host CPU 11 monitors a voltage waveform of the backup power after tuning on the HDD power switch. When the backup power voltage is lowered, a normal-unload instruction is issued to the CPU 152 of the HDD controller 26.

Next, the HDD-built CPU 152 carries out the following process according to a control instruction by the host CPU 11. First, instructed for normal unload (step S51), the HDD-built CPU 152 decodes the instruction. If, at this moment, the HDD is within either the write or read operation mode, the CPU 152 causes to move the magnetic head 51 toward the outer periphery (step S52). Then, monitor is made on whether the magnetic head 51 has reached the outermost periphery or not (step S53). When reaching the outermost periphery is confirmed, a process is made to cause the magnetic head 51 to climb the ramp 55 (step S54).

If the both voltages of the backup power and ACC power drop below 4.5V and the emergency unload operation is effected, the magnetic head 51 is moved toward the outermost periphery by the reverse electromotive force of the spindle motor 161 so that is climbs the ramp 55.

In this manner, the emergency unload is effected via the normal unload when the backup voltage drops under the state where the ACC power is supplied.

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The operation of the magnetic head in such a case will be explained with reference to Figs. 9A and 9B.

First, the magnetic head 51 when the voltage value α of the backup power is a steady voltage of 12V is assumed in a position hatched in Fig. 9A. If in this position the backup power voltage value α goes below 9V, the normal unload is initiated. This moves the magnetic head 51 in a direction shown by the arrow in Fig. 9A. The movement of the magnetic head 51 is continued until the backup power voltage becomes 4.5V. In Fig. 9A, the backup power voltage is assumed to drop to 4.5V where the magnetic head 51 comes to a dot-lined position.

Next, when the backup power voltage value α becomes below 4.5 V, the emergency unload is started (Fig. 9B). This moves the magnetic head 51 in a direction shown by the arrow in Fig. 9B. That is, the emergency unload is started from the hatched position of the magnetic head 51 in Fig. 9B and then the unload operation completes upon running over the ramp 55.

The magnetic head 51 collides with a taper 56 of the ramp 55, an impact degree of which is in proportion to a distance between the magnetic head 51 and the ramp 55, i.e. the impact degree is greater as the magnetic head 51 and the ramp 55 are distant farer. Consequently, where the normal unload is made immediately before the emergency unload, the magnetic head 51 is moved even a little toward the outer periphery thus relaxing the impact of collision between the magnetic head 51 and the ramp 55.

As explained above, the present invention moves the head

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in the direction toward the outer periphery when power voltage drop is detected in a range of no occurrence of emergency unload. Even when thereafter emergency unload is effected, the impact caused upon collision of the head with the taper of the ramp is relaxed thus prevent the lifetime of the HDD to be shortened.

Incidentally, the foregoing normal-unload operation by the HDD device is to be effected not only at an engine startup but also in an event of power-voltage drop after starting the engine.

As explained above, in the disk drive apparatus according to the present invention, detected is a voltage immediately before occurrence of the emergency unload caused by an abrupt decrease in the power voltage. When the voltage drop is detected, the magnetic head is first moved in a direction toward an outer periphery, and thereafter the emergency unload is carried out. This can relax the impact caused upon collision of the magnetic head with a taper of a ramp, thus enhancing endurance and improving reliability.

This application is based on a Japanese Patent Application No. 2000-123263 which is hereby incorporated by reference.

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